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DEPARTMENT OF THE ARMY

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BAUSCH & LOMB INCORPORATED

Project 8F23-11-001-05

Contract DA-44-009-ENG-4954

15 August to 15 November 1962

INFRARED COATING STUDIES

THIRD QUARTER REPORT 1962



DC 56433

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### Introduction

This third quarterly report contains three sections. The first is a continuation of the survey of measured reflectances of materials in the reststrahlen region to 36 microns as begun in the Third Quarter Report, 1 July 1961 - 1 October 1961, on Contract DA-44-009-ENG-4686. In the second section there is a cumulative index of all reflectance curves to date from the present and preceding contract. The third section lists technical papers prepared on the basis of the work on these two contracts, and outlines preparations for an upcoming experiment.

SECTION I

Survey of The Reststrahlen Region to 36 Microns (Continued)

Twelve new figures of measured reststrahlen reflectances are included in this report. Unpolarized radiation was used, as heretofore, and in general the crystallographic orientation of the polished surfaces of the samples was not determined. Both of these factors would need to be accounted for in any exact analysis, which is beyond the intent of this survey.

Comments on Figures

Fig. 1 - Nickel sulfate hexahydrate crystal  $\text{NiSO}_4 \cdot 6\text{H}_2\text{O}$ .

Fig. 2 - Potassium dihydrogenphosphate (KDP) crystal  $\text{KH}_2\text{PO}_4$ .

Fig. 3 - Sodium aluminum fluorides

Cryolite translucent natural crystal  $3\text{NaF} \cdot \text{AlF}_3$ .  
Chiolite clear natural crystal  $5\text{NaF} \cdot 3\text{AlF}_3$ .

Fig. 4 - Tin oxide - dark mineral nodule of cassiterite  $\text{SnO}_2$ .

Fig. 5 - Labradorite - blue iridescent mineral  $\text{NaAlSi}_3\text{O}_8$ .  
 $\text{CaAl}_2\text{Si}_2\text{O}_8$ .

Fig. 6 - Garnet - red mineral rock (Almandine  $\text{Fe}_3\text{Al}_2\text{Si}_3\text{O}_{12}$ ).

Fig. 7 - Chert - bluegreen variety from the Coxsackie Flint Mine - microscopically grained quartz.  
A grey variety from Finger Lakes Site Can 29-3 gave substantially the same curve.

Fig. 8 - Tiger's Eye - yellow mineral with play of light, a variety of quartz.

Fig. 9 - Petrified wood - red color

Except for small differences in intensity this curve matched the curves of a light buff colored sample and a very dark grey sample.

The kinship between Chert, Tiger's Eye and Petrified Wood is apparent from Figs. 7-9, the structure in the 8-14  $\mu$  region being very similar. The doublet peaks at 8.5 and 9.5 microns are characteristic of a microcrystalline quartz composition (cf. C. Schaefer and F. Matossi, Das Ultrarote Spektrum, Berlin 1930, p. 318).

Fig. 10 - Bismuth selenide  $\text{Bi}_2\text{Se}_3$ .

Fig. 11 - Molybdenum disilicide  $\text{MoSi}_2$ .

Fig. 12 - Silicate glass Bausch & Lomb IR-2

Germanate glass Bausch & Lomb IR-20

The peak in the silicate glass at 11 microns is displaced to 13 microns in the germanate glass because the atomic weight of the germanium is greater than that of the silicon.

Note: References to the minerals mentioned above (except Tiger's Eye) may be found in "A Field Guide to Rocks and Minerals, Frederick H. Pough, 3rd Edition Houghton Mifflin Co., Boston.

SECTION II

Cumulative Index of Reststrahlen Curves as Reported  
In This Contract Series

To date more than 30 reflectance curves of various materials have been measured throughout the reststrahlen region to 36 microns and reported in this contract series. The following index has been tabulated to aid in locating them. It will be supplemented in the future as more curves are obtained.

Cumulative Reststrahlen Index to November 15, 1962

To December 1961 - Contract DA-44-009 ENG 4686

To January 1963 - Contract DA-44-009-ENG 4954

<u>Material</u>	<u>Form</u>	<u>Quarterly Report</u>	<u>Contract</u>	<u>λ in μ</u>	<u>Fig.</u>
Barium Fluoride	BaF <sub>2</sub> Crystal	II, 1961	4686	14-36	1
		III, 1961	4686	14-36	5
		Hot pressed IV, 1961	4686	14-36	4
Bismuth Selenide	BiSe	IV, 1961	4686	14-36	10
		III, 1962	4954	4-36	10
Bismuth Telluride	BiTe	IV, 1961	4686	14-36	10
Calcium Fluoride	CaF <sub>2</sub> Crystal	III, 1961	4686	14-36	2-3-4
Cassiterite	SnO <sub>2</sub> Mineral	III, 1962	4954	4-36	4
Chert	SiO <sub>2</sub> Rock	III, 1962	4954	4-36	7
Chiolite	5NaF·3AlF <sub>3</sub> Crystal	III, 1962	4954	4-36	3
Cryolite	3NaF·AlF <sub>3</sub> Crystal	I, 1962	4686	14-36	15
		III, 1962	4954	4-36	3
Gallium Arsenide	GaAs	I, 1962	4686	14-36	13
Garnet	Mineral rock	III, 1962	4954	4-36	6

<u>Material</u>	<u>Form</u>	<u>Quarterly Report</u>	<u>Contract</u>	<u><math>\lambda</math> in <math>\mu</math></u>	<u>Fig.</u>
Germanium	Ge Polycrystalline	IV, 1961	4686	14-36	9
<u>GLASSES</u>					
Arsenic Trisulfide	As <sub>2</sub> S <sub>3</sub>	IV, 1961	4686	14-36	8
EDF-2	B&L I	IV, 1961	4686	14-36	7
IRTRAN II	E.K. Co.	IV, 1961	4686	14-36	6
IR-2 (Silicate)	B&L I	III, 1962	4954	4-36	12
IR-20 (Germanate)	B&L I	III, 1962	4954	4-36	12
Graphite	C	IV, 1961	4686	14-36	9
Labradorite	Mineral rock	III, 1962	4954	4-36	5
Lead Telluride	PbTe Polycrystalline	IV, 1961	4686	14-36	10
Lithium Fluoride	LiF Crystal	IV, 1961	4686	14-36	1 A&B
	Thin Film	I, 1962	4954	14-36	5
Magnesium Fluoride	MgF <sub>2</sub> Hot pressed	III, 1961	4686	14-36	7
Magnesium Oxide	MgO Crystal	III, 1961	4686	14-36	8
Molybdenum disilicide	MoSi <sub>2</sub>	III, 1962	4954	4-36	11
Nickel Sulfate	NiSO <sub>4</sub> ·6H <sub>2</sub> O Crystal	III, 1962	4954	4-36	1
Petrified Wood	SiO <sub>2</sub>	III, 1962	4954	4-36	9
Potassium di Hydrogen Orthophosphate	KH <sub>2</sub> PO <sub>4</sub> Crystal	III, 1962	4954	4-36	2
Quartz	SiO <sub>2</sub> Fused	III, 1961	4686	14-36	6
	Fused & Crystal	IV, 1961	4686	14-36	3 & 17
Sapphire	Al <sub>2</sub> O <sub>3</sub>	IV, 1961	4686	14-36	2

<u>Material</u>		<u>Form</u>	<u>Quarterly Report</u>	<u>Contract</u>	<u>in <math>\mu</math></u>	<u>Fig.</u>
Silicon	Si		IV, 1961	4686	14-36	9
Strontium Fluoride	SrF <sub>2</sub>	Hot pressed	IV, 1961	4686	14-36	5
Strontium Titanate	SrTiO <sub>3</sub>	Crystal	I, 1962	4954	14-36	16
Tiger's Eye	SiO <sub>2</sub>	Mineral	III, 1962	4954	14-36	8
Zinc Sulfide	ZnS	Syn. Crystal	I, 1962	4686	14-36	14

SECTION III

Various Contract Activities

The work of this and the preceding contract lead to two papers in this Third Quarter:


1. "Effect of Crystallite Size on the Infrared Dispersion of LiF" by T. Patrick Martin, Master's Thesis, Pennsylvania State University, dated December 1962.
2. "Reststrahlen Bands of Evaporated Films" by T. P. Martin, A. F. Turner, J. Masso and F. Sulzbach, Paper WA11, October 1962 Meeting of the Optical Society of America, Rochester, N.Y.

Evaporation equipment has been constructed for the following experiment relating to crystallite size in films and the interpretation of x-ray diffraction line broadening. Line broadening may be due to either a restriction on crystallite size in an evaporated film, or to internal strains or to both. It is proposed to produce evaporated films of LiF and of other materials, of restricted thickness, say 1000Å, but at a sufficiently high substrate temperature which is known by x-ray evidence to permit the growth of crystallites of much greater dimensions in thick films. The thickness of the thin films of this experiment will be measured, and they will then be removed from the substrate to be powdered and compacted in a plate form to a thickness sufficient to give reststrahlen reflectance curves. From previous experience it is expected that the platelet film particles will be substantially parallel to the surfaces of the compacted plate. X-ray diffraction line broadening should then correspond to the measured thickness of the original film if strain

broadening is of secondary importance.

This report was prepared by F. Sulzbach and A. F. Turner.

Submitted by

A handwritten signature in cursive script, appearing to read "A. F. Turner".

A. Francis Turner, Head

Vacuum Coating Research Laboratories

Materials Research and Development

MEASURED REFLECTANCE OF  $\text{NiSO}_4 \cdot 6\text{H}_2\text{O}$

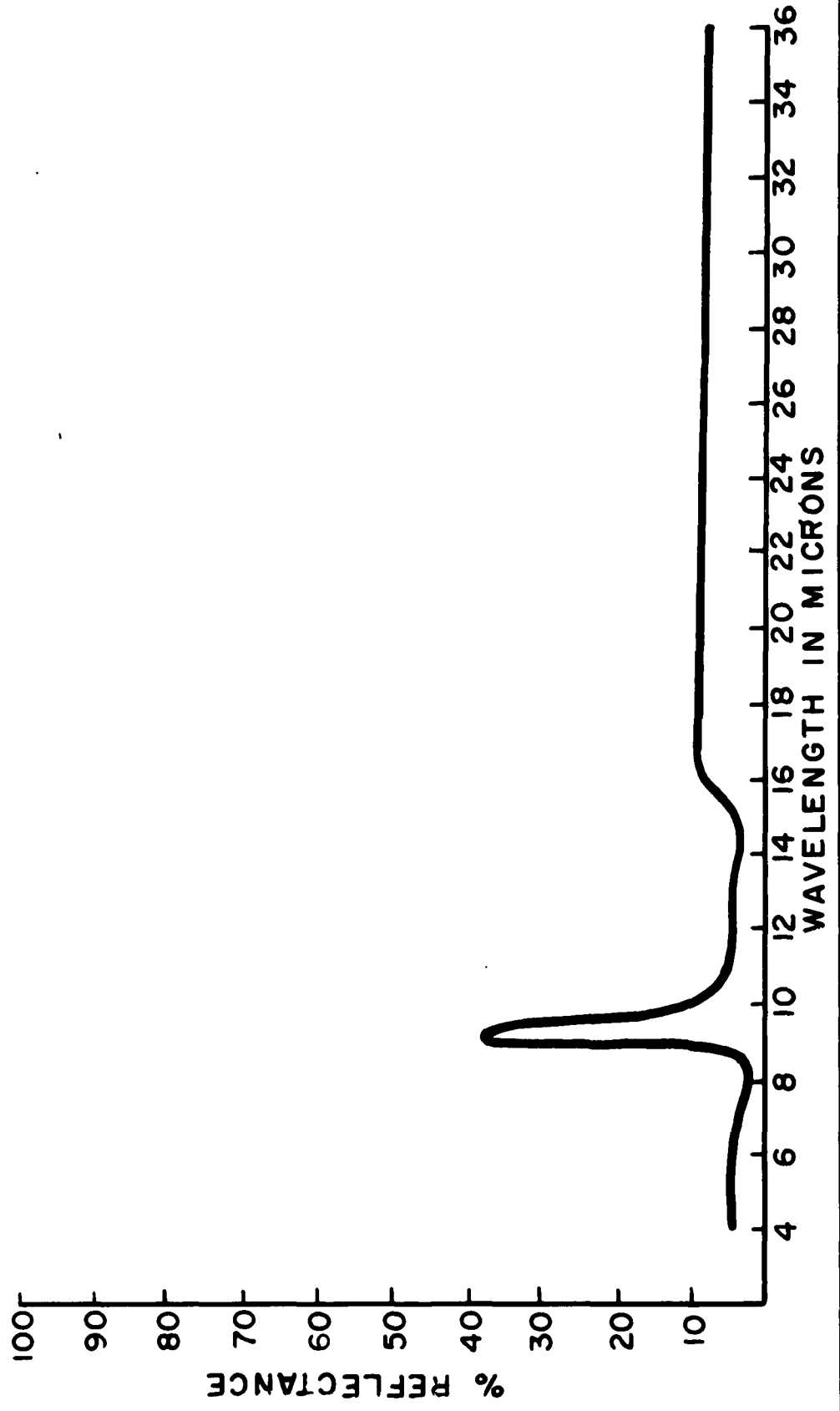


FIG. 1

# MEASURED REFLECTANCE OF KDP

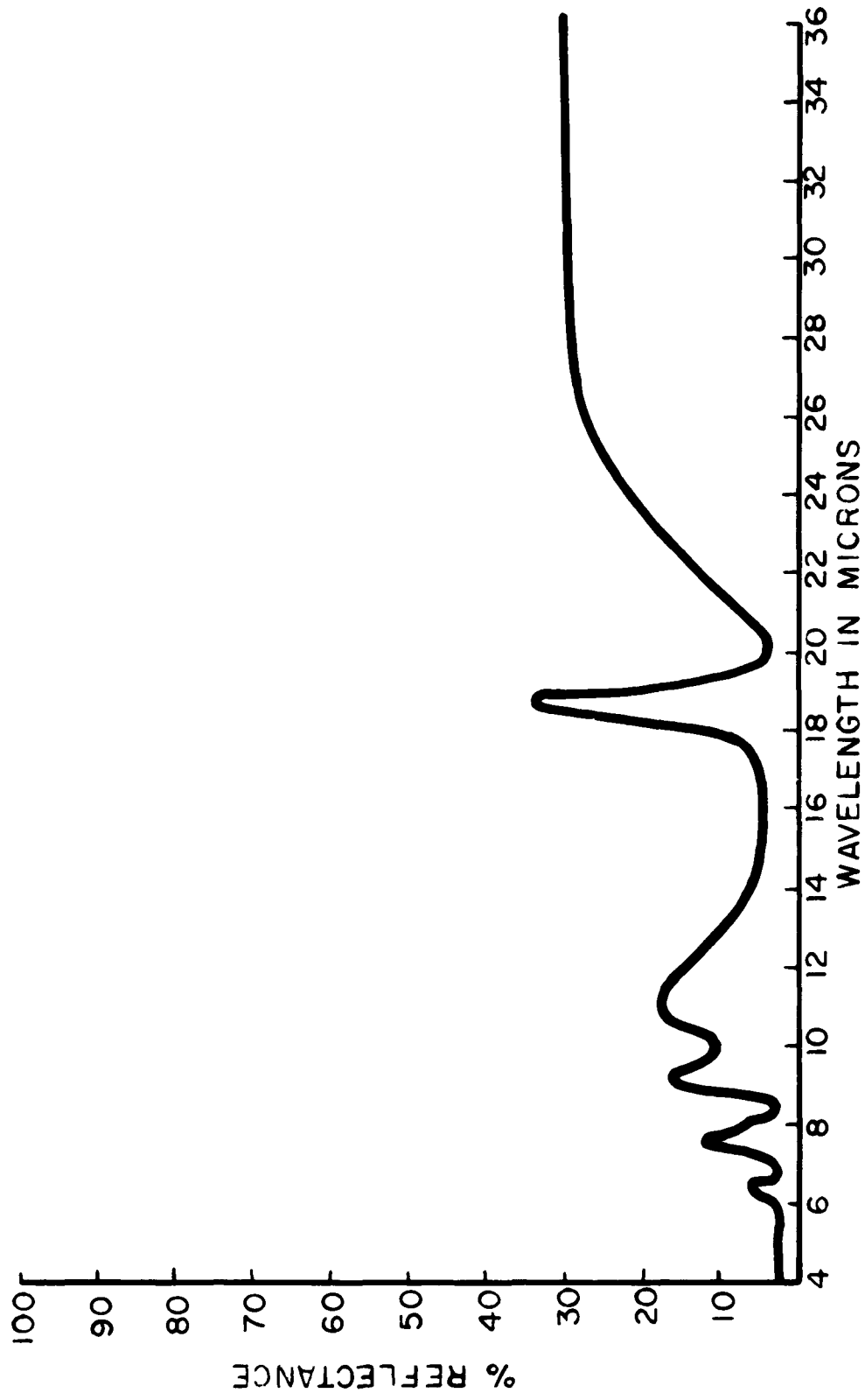


FIG. 2

MEASURED REFLECTANCE OF CHIOLITE (SOLID LINE)  
AND CRYOLITE (DOTTED LINE)

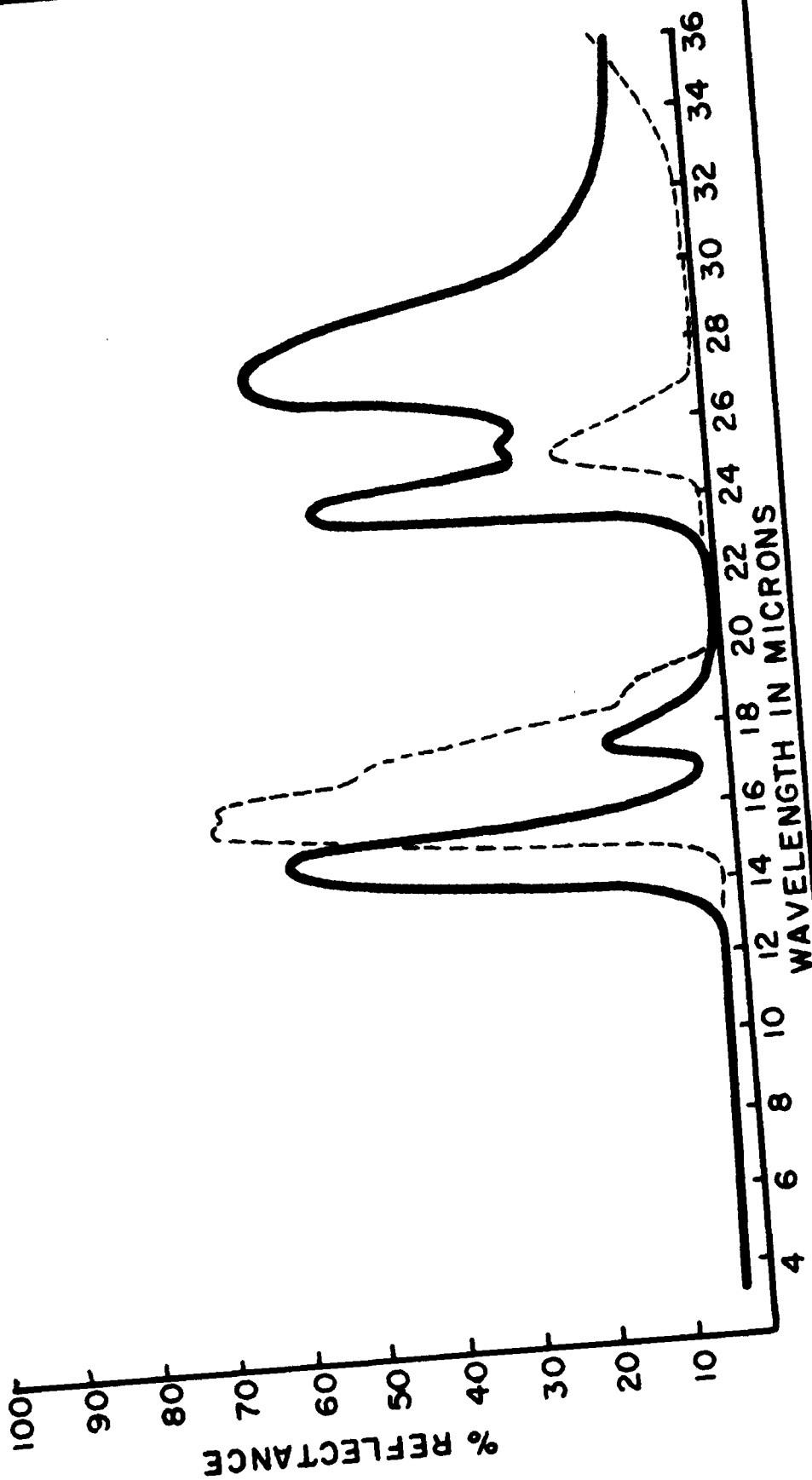


FIG. 3

# MEASURED REFLECTANCE OF CASSITERITE ( $\text{SnO}_2$ )

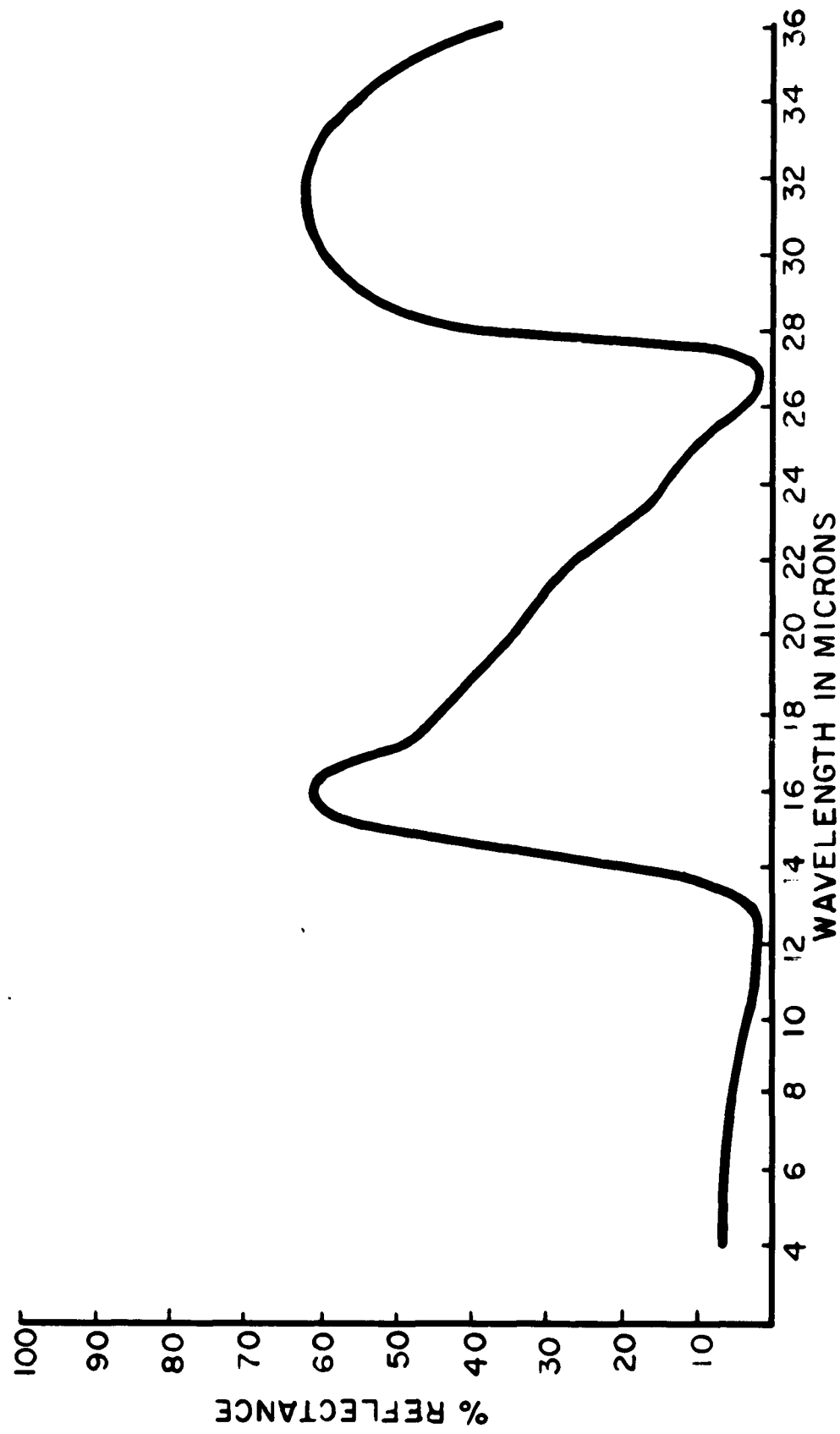


FIG. 4

# MEASURED REFLECTANCE OF LABRADORITE

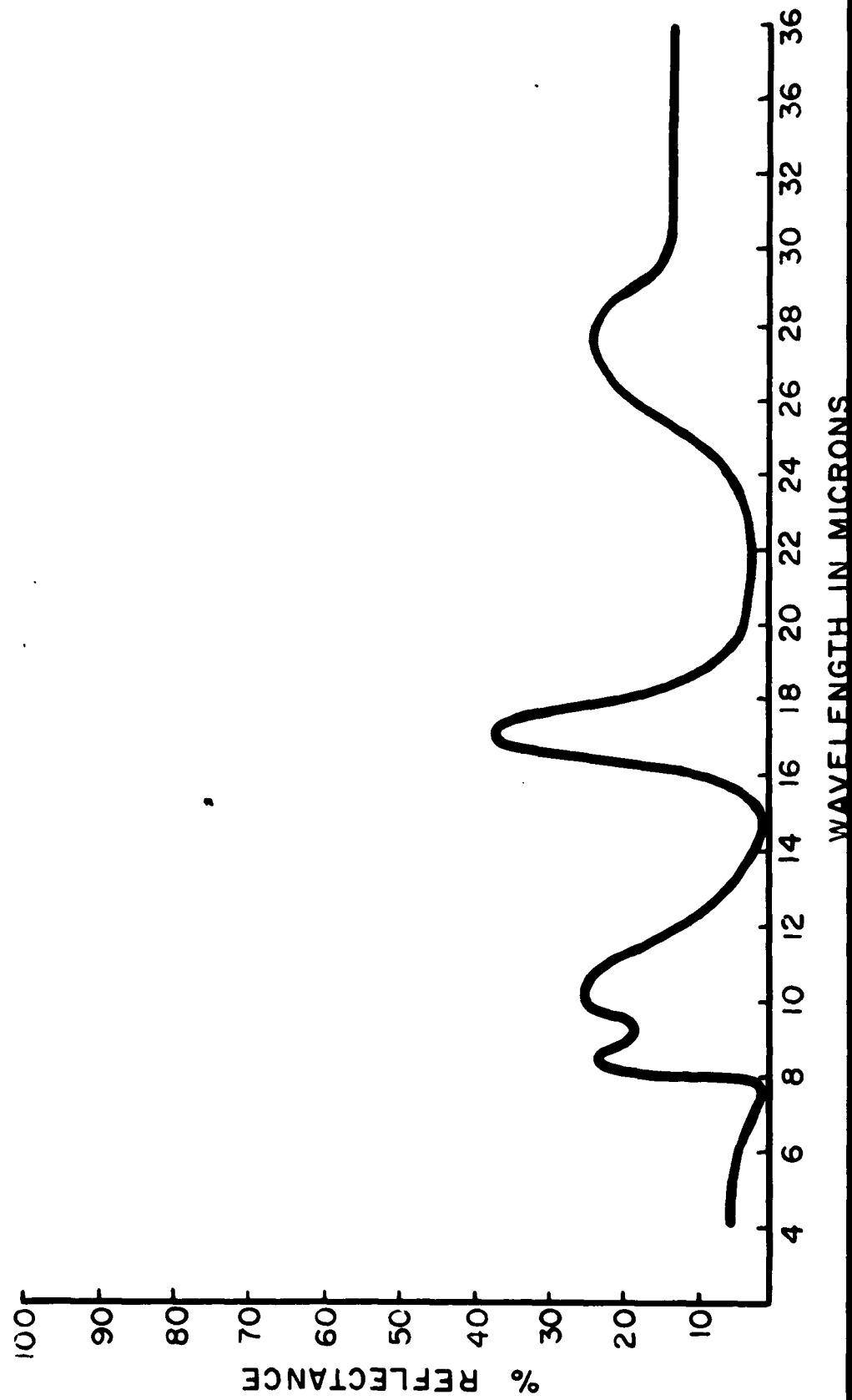


FIG. 5

# MEASURED REFLECTANCE OF GARNET

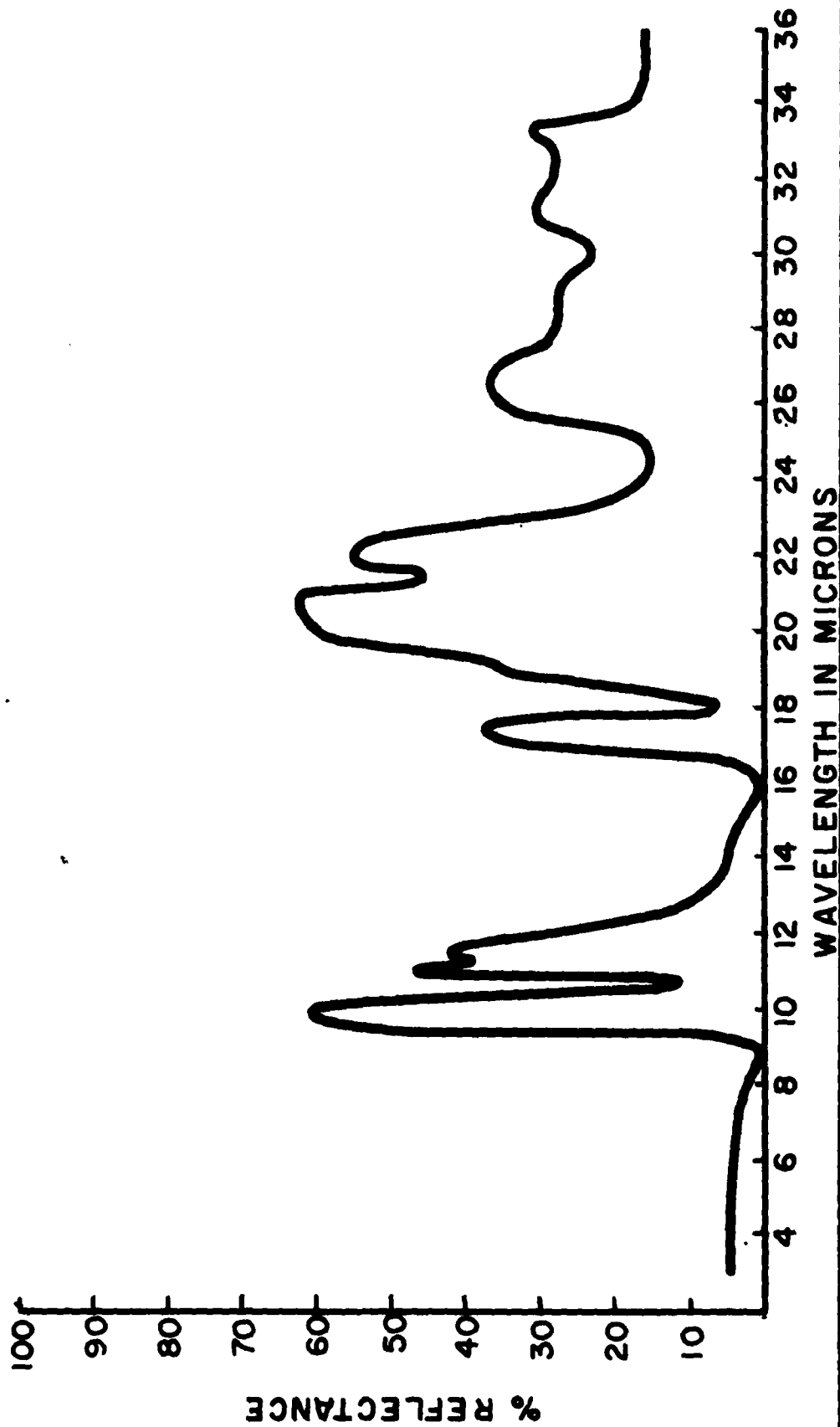


FIG. 6

MEASURED REFLECTANCE OF CHERT (COXSACKIE FLINT MINE)

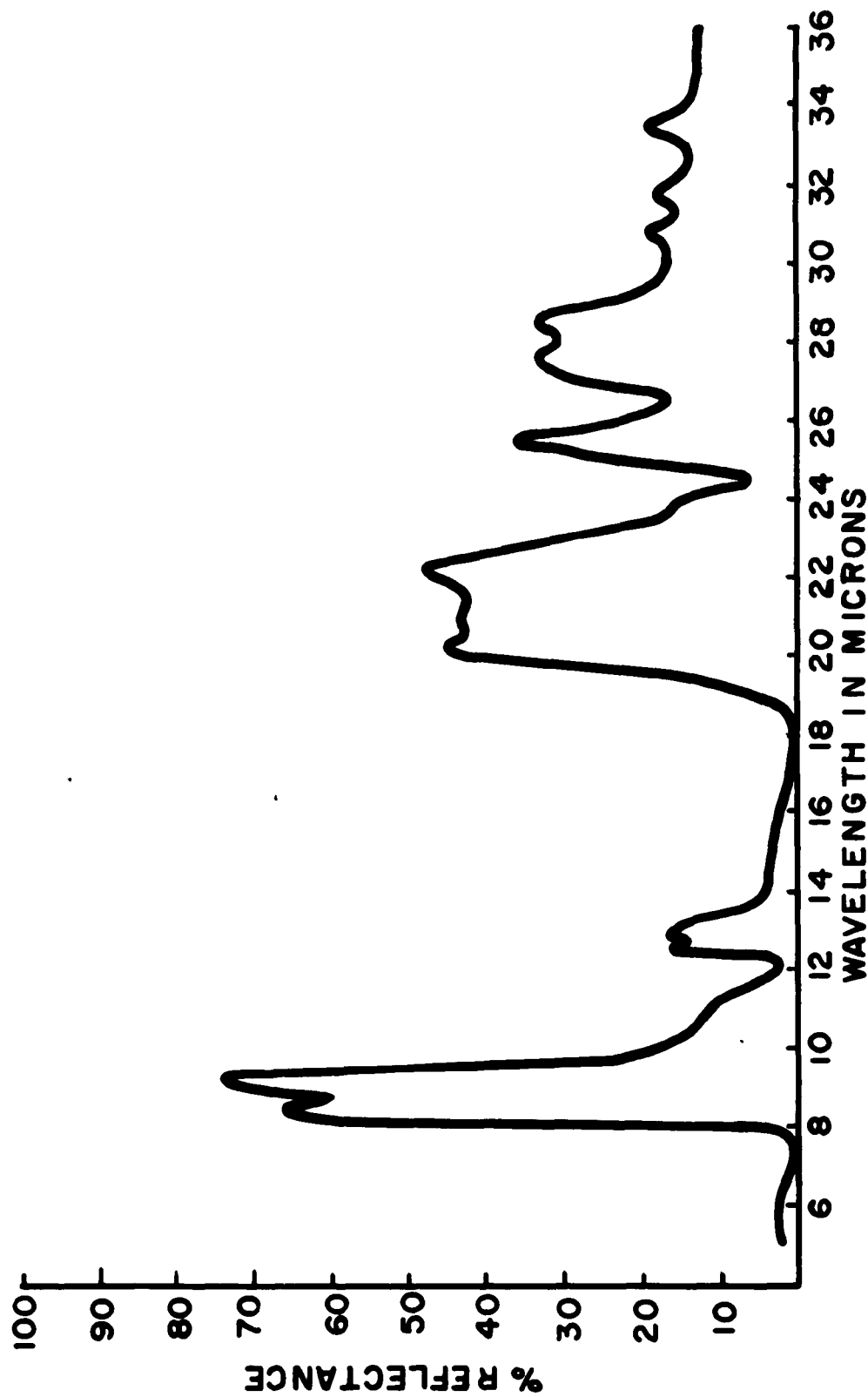


FIG. 7

MEASURED REFLECTANCE OF TIGER'S EYE ( $\text{SiO}_2$ )

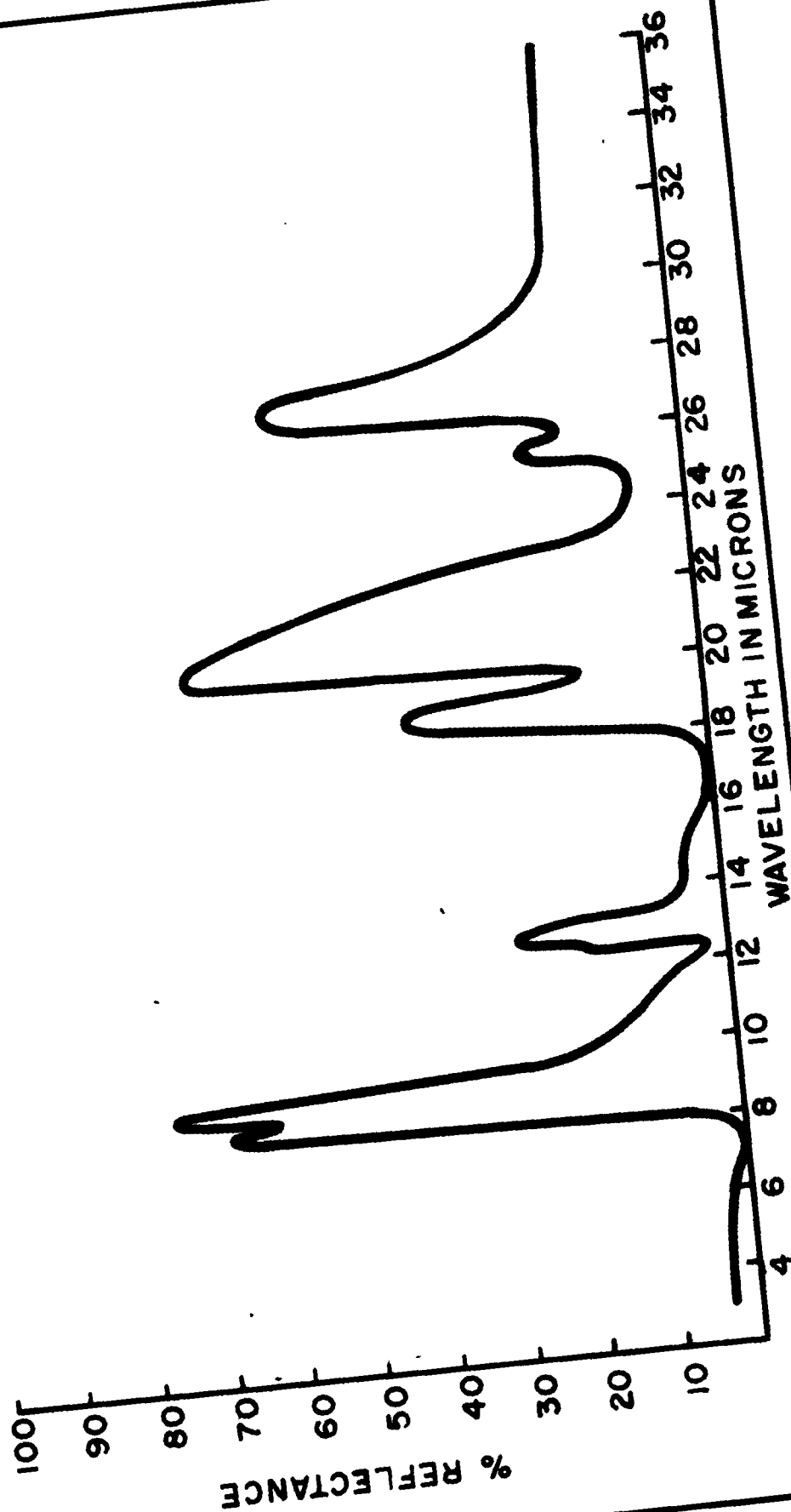


FIG. 8

# MEASURED REFLECTANCE OF PETRIFIED WOOD

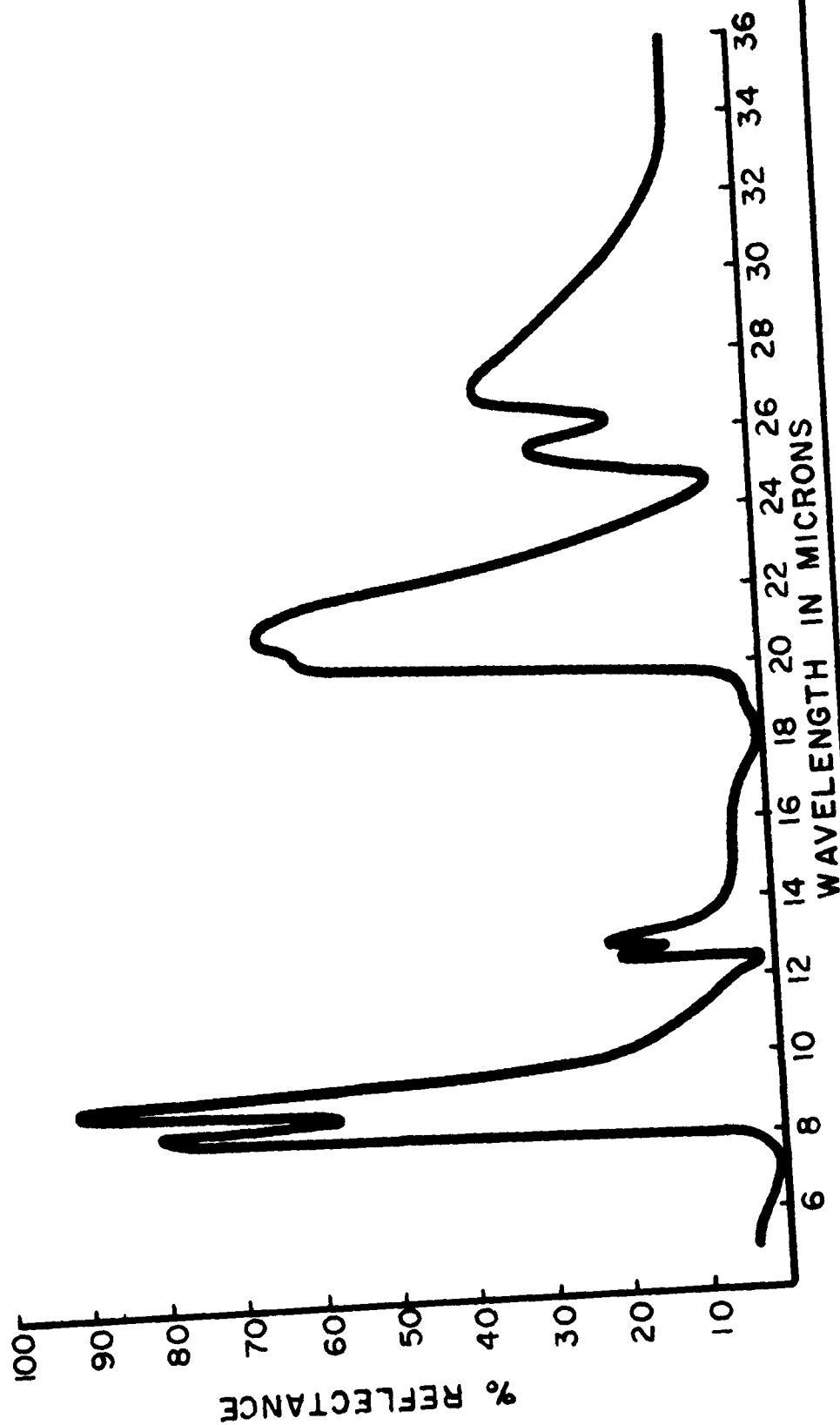


FIG. 9

# MEASURED REFLECTANCE OF BISMUTH SELENIDE

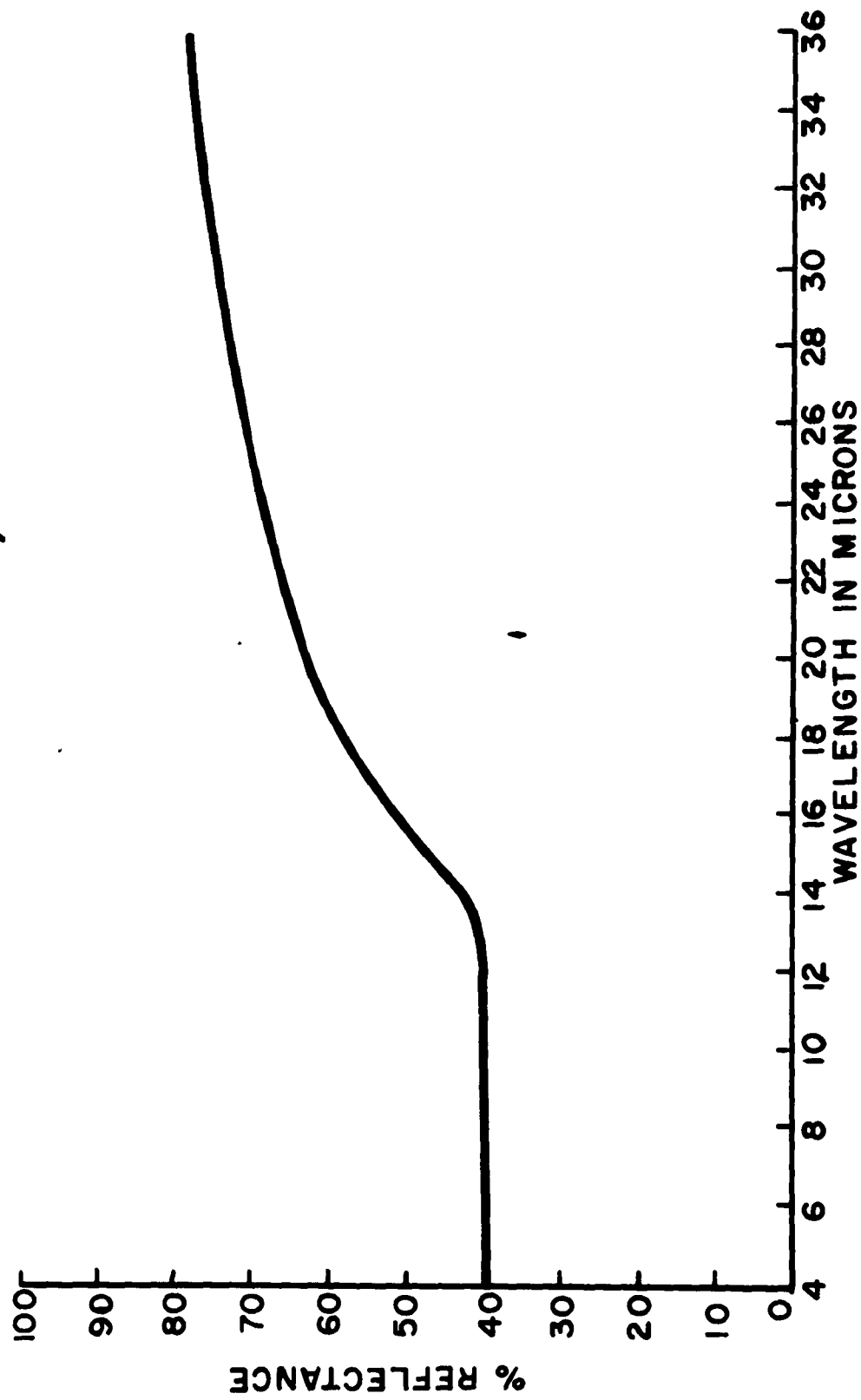


FIG. 10

# MEASURED REFLECTANCE OF MOLYBDENUM DISILICIDE

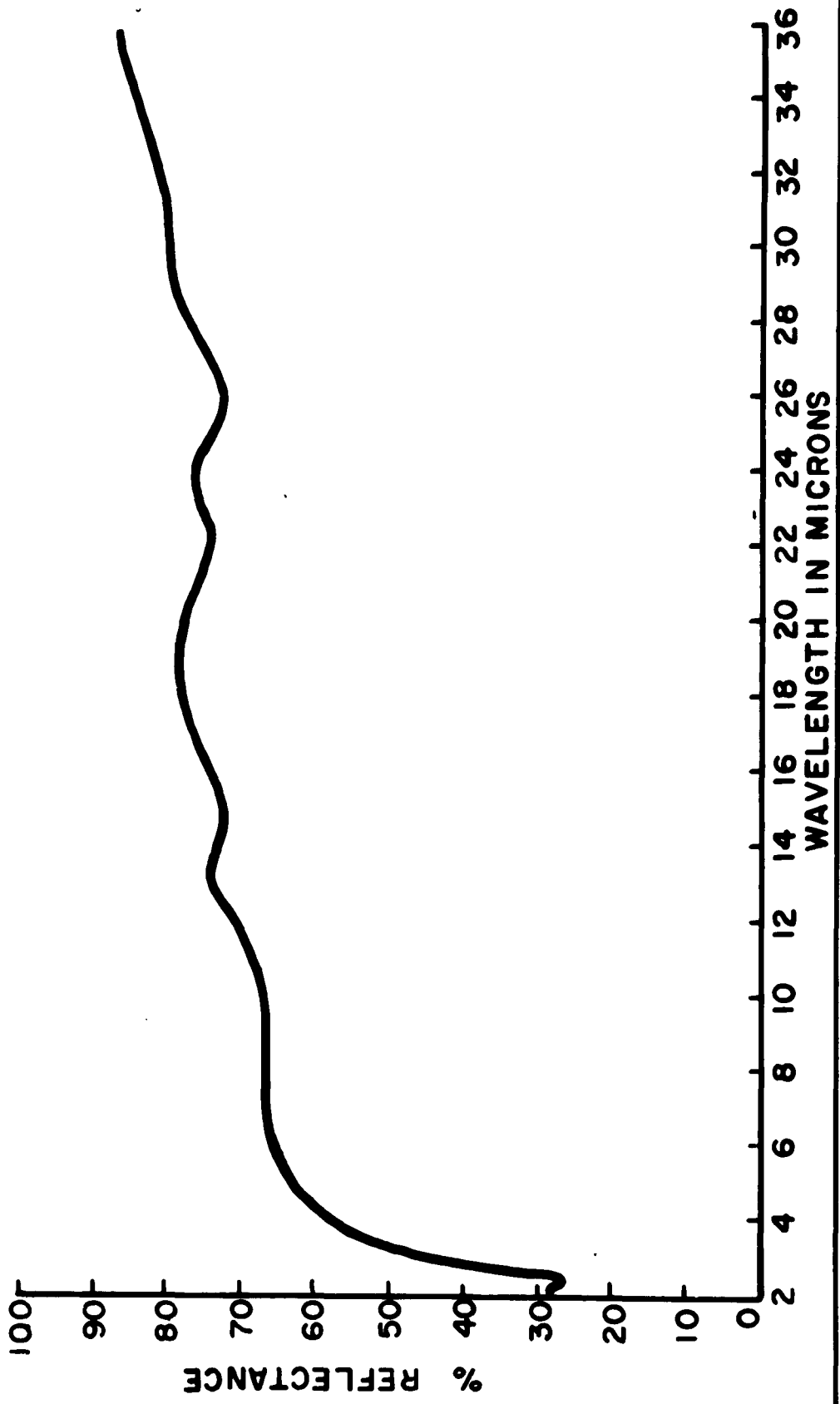


FIG. 11

MEASURED REFLECTANCE OF IR-2 (SILICATE) GLASS —  
IR-20 (GERMANATE) GLASS ---

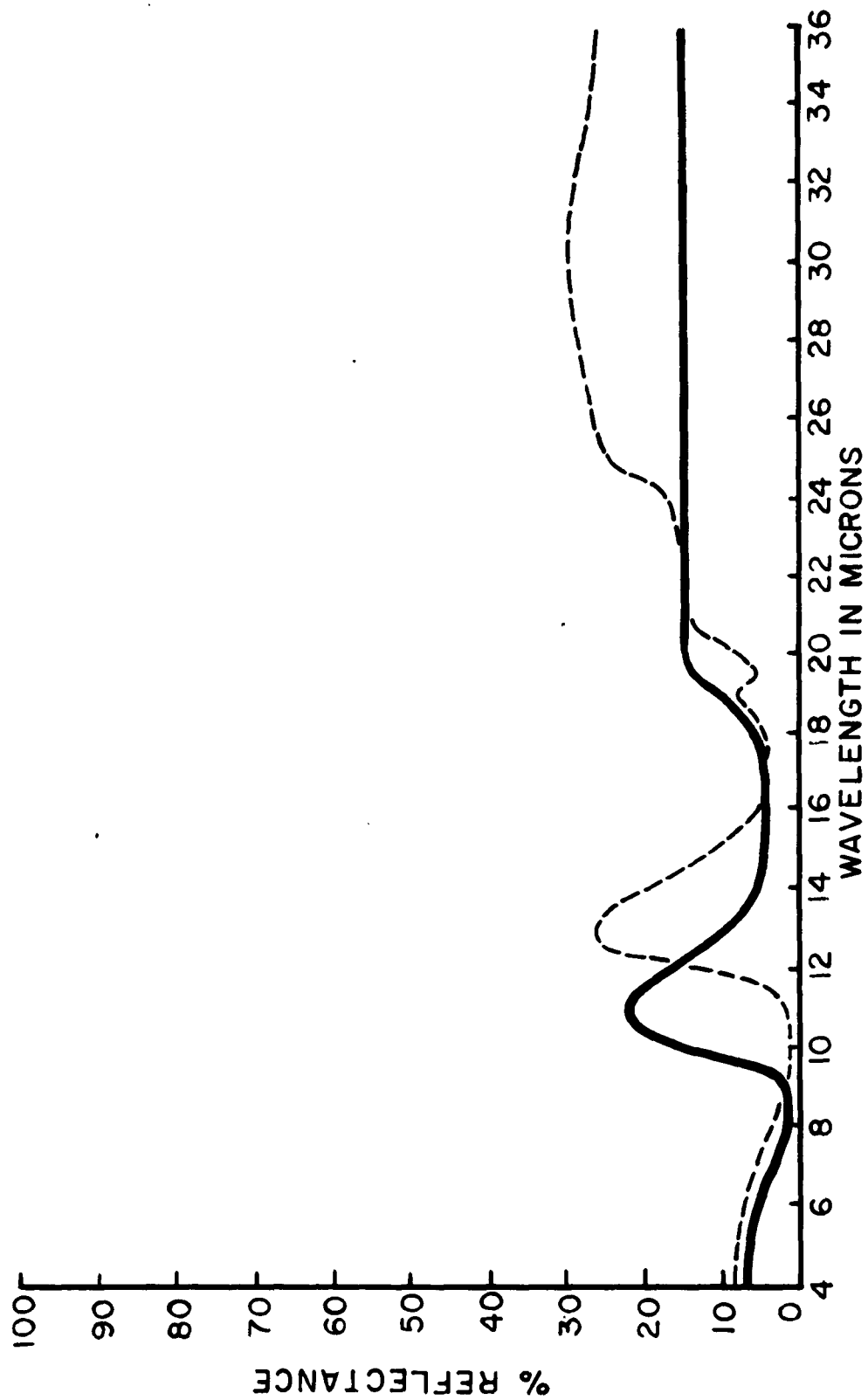


FIG. 12